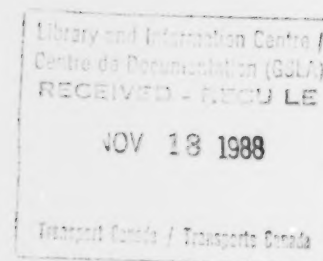


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**Evaluation Report on
Alternative Systems for Processing
International Solid Waste
at
Pearson International Airport**



prepared for the
**Transportation Development Centre
Transport Canada**

by
**MacLaren Engineers Inc.
Lavalin Inc.**

September 1988

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The contents of this report reflect the views of MacLaren Engineers Inc. and not necessarily the official view or opinions of the Transportation Development Centre of Transport Canada.

Un sommaire en français de ce rapport est inclus avant la Table des matières.



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17. Abstract The objective of this research was to review and evaluate technology options for the disposal of airside solid waste from international flights arriving at Lester B. Pearson International Airport in Toronto. A thermal compression system (thermopress) installed by the airlines has been problematic — the system is not meeting Agriculture Canada requirements and approximately 720 to 900 tonnes of waste (processed and raw) have accumulated. Two other options were evaluated: wet oxidation and destructive distillation. These two technologies, as well as autoclaving, irradiation and incineration, were recommended for further evaluation. Because all three primary options are still under development, no system was recommended over the other two. It was concluded that Agriculture Canada requirements to treat international airside waste would adequately protect animals and livestock from foreign diseases but may not protect the waste handlers and the population in the vicinity of the ultimate landfill. Some consideration should be made of either increasing the temperature or extending the length of exposure time of the products to ensure sterility. It was also concluded that the problems facing the thermopress system have become so critical that an immediate solution (e.g., advanced-design mobile incinerator) is recommended for evaluation and implementation as soon as possible.			
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17. Résumé La recherche dont il est rendu compte concerne l'évaluation des procédés proposés pour l'élimination des déchets solides issus de vols internationaux arrivant à l'aéroport international Lester B. Pearson de Toronto. Le système de compactage thermique (thermopress), provisoirement installé à la demande des transporteurs, pose des problèmes du fait qu'il ne répond pas à la réglementation d'Agriculture Canada et que de 720 à 900 tonnes de déchets (traités ou bruts) se sont maintenant accumulés. Deux procédés de rechange ont été examinés : oxydation par voie humide et distillation sèche; toutefois, comme ceux de l'irradiation, de l'incinération et du traitement par autoclave, ils méritent une évaluation plus approfondie. Étant donné que les trois procédés principaux évalués ne sont pas encore tout à fait au point, il n'a pas été possible de se prononcer définitivement en faveur de l'un ou de l'autre. La recherche a démontré que la réglementation d'Agriculture Canada concernant le traitement des déchets solides issus des vols internationaux assure la protection adéquate des animaux et du bétail contre des pathologies importées; il n'en est cependant pas de même pour ceux qui manipulent ces déchets ni pour la population vivant à proximité du dépotoir où seront acheminés les résidus du procédé. Ce problème pourrait être réglé par l'accroissement de la température de traitement ou de la durée de maintien à celle-ci, afin d'aboutir à une stérilisation complète des déchets. Enfin, devant la situation de plus en plus critique créée par l'utilisation du système thermopress, le rapport propose l'évaluation et l'adoption d'une solution provisoire le plus tôt possible, soit l'utilisation d'un incinérateur mobile de type avancé.			
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SUMMARY

In July of 1988, MacLaren Engineers Inc. were retained by the Transportation Development Centre of Transport Canada to evaluate the capabilities of several technology options available for treating solid waste (including wastes from international aircraft, domestic aircraft and food preparation) as well as other wastes (including washdown glycols used for de-icing, fuel spills, sanitary waste, and run-off from fire fighting effluent) at Lester B. Pearson International Airport in Toronto.

The need for this evaluation report was precipitated by the closing of the Commissioner Street Incinerator in Toronto on July 31, 1988. The Commissioner Street plant had up to that time been used to incinerate municipal waste and the airport's solid waste but was closed in response to public concern with the plant's air emissions.

The technology options that have been considered in this report represent alternatives to incineration. The evaluated technology options include the Econoler System (thermopress) presently installed in temporary form at the Airport by the Airline Committee, as well as two other alternatives: the Kenox system (wet oxidation) and the Waste Distillation Technology system (destructive distillation).

Each technology was assessed for its technical feasibility and conformance with applicable regulations. Environmental impact, commercial aspects and related experience were examined. Other technologies deemed by MacLaren Engineers as being worthy of consideration for this application were highlighted for future consideration. These other technologies were not directly evaluated against the three base systems.

MacLaren Engineers held meetings with suppliers of each of the three systems mentioned above in order to obtain as much information as possible. This supplemented existing information available concerning each system, which in general was minimal and not project specific. The three systems were then summarized, indicating the pros and cons of each alternative. Specific findings such as operating temperatures retention times, capital and operation and maintenance costs, environmental concerns, safety concerns, etc. are presented in a Summary Table.

In general, the wet oxidation and destructive distillation systems appeared superior to the thermopress on the basis of their lower life cycle costs and their greater likelihood to render all micro-organisms associated with the airport waste safe.

In light of this latter concern, this report recommends, as a short-term consideration, that a rigorous testing program be established to verify that the installed thermopress system is capable of rendering all micro-organisms completely harmless. A further recommendation, also for short-term consideration, is to examine the op-

tion of installing a transportable, temporary incinerator to process all accumulated solid waste until a long-term solution is developed.

To establish a long-term strategy, the report recommends that a feasibility study be conducted to develop the necessary information required to assess the suitability of the wet oxidation system, the destructive distillation system, and other technologies including autoclaving, irradiation and incineration.

Although the original scope of this report was to examine alternatives to incineration, MacLaren Engineers recommends that incineration be seriously considered given that it has been widely used and proven for this type of application. Negative public reaction to any incineration alternative proposed can be expected.

SOMMAIRE

En juillet 1988, le Centre de développement des transports, Transports Canada, a chargé la firme MacLaren Engineers Inc. de faire l'évaluation de certains procédés connus pour le traitement des déchets solides produits à l'aéroport international Lester B. Pearson de Toronto. Le terme déchets solides comprend aussi bien ceux qui proviennent des vols internationaux et nationaux et de la préparation des repas, que d'autres types de déchets résiduels, comme les solutions glycolées utilisées pour le déverglaçage des avions, les déversements accidentels d'hydrocarbures, les déchets sanitaires et les agents chimiques utilisés pour l'extinction d'incendies.

Le besoin pour une telle évaluation s'est fait sentir à la suite de la fermeture, le 31 juillet 1988, de l'incinérateur de la rue Commissioner à Toronto, lequel servait à l'incinération des déchets tant municipaux qu'aéroportuaires. Celui-ci a dû être fermé suite à l'inquiétude générale sur la pollution de l'air qu'il pouvait causer.

Les technologies prises en compte dans ce rapport et destinées à remplacer l'incinération sont les suivantes : Système Econoler (thermopress) adopté provisoirement par le comité aéroportuaire spécial; deux autres : le système Kenox (oxydation par voie humide) et le procédé de Waste Distillation Technology Inc. (distillation sèche).

L'évaluation de chaque procédé a porté sur sa faisabilité et sa conformité à la réglementation applicable; elle a aussi tenu compte de l'impact sur l'environnement, de l'aspect commercial et des applications en cours. D'autres technologies qui mériteraient d'être considérées, selon les ingénieurs de MacLaren, ont été signalées sans plus, c'est-à-dire qu'elles n'ont pas été évaluées comme les trois autres.

Le contractant a cherché auprès des fournisseurs un supplément d'information sur les trois technologies en présence, étant donné que l'information disponible à leur sujet n'était ni abondante ni spécifique à l'application envisagée. L'évaluation qu'il en a tiré par la suite a permis d'en cerner les avantages et les inconvénients; ces données ont été mises dans un tableau résumant les principales caractéristiques comme : la durée de maintien de la température, les coûts de premier établissement, d'exploitation et d'entretien, l'impact sur l'environnement, la sécurité, etc.

En gros, les procédés d'oxydation par voie humide et de distillation sèche ont semblé surclasser le procédé thermopress, d'une part, parce qu'ils dégagent un coût global inférieur à celui-ci et, d'autre part, en raison de la plus grande probabilité que tous les micro-organismes trouvés dans les déchets produits par les aéroports soient effectivement neutralisés.

À ce propos, le rapport recommande pour le court terme que des essais rigoureux soient menés dans le but de vérifier la capacité du système thermopress provisoirement en place de détruire complètement tous les micro-organismes. Autre recommandation : que soit examinée la possibilité d'utiliser, à titre provisoire, un incinérateur transportable pour le traitement de tous les déchets solides accumulés, en attendant l'adoption d'une solution permanente.

Pour ce qui est du long terme, la rapport recommande que soit lancée une étude de faisabilité en vue de recueillir l'information devant permettre d'évaluer les deux procédés d'oxydation par voie humide et de distillation sèche, ainsi que d'autres comme l'irradiation, l'incinération et le traitement par autoclave.

Bien que la recherche visait essentiellement l'évaluation de solutions de rechange à l'incinération, le contractant n'en propose pas moins que cette dernière soit sérieusement prise en considération étant donné qu'elle est universellement utilisée et a fait ses preuves dans cette application. Il faut toutefois s'attendre à une réaction négative de la part du public.

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REFERENCE LIST

1.0 GENERAL BACKGROUND

The Transportation Development Centre (TDC) of Transport Canada retained MacLaren Engineers Inc. through Lavalin Transport Inc. to review technology options considered as alternatives to incineration, for processing international solid waste at Pearson International Airport.

The international solid waste (Airside Waste) has been incinerated at the Commissioner Street Incinerator up to July 31, 1988, at which time the incinerator was closed in response to public concern with the air emissions from the plant.

The Airline Committee at the Pearson International Airport initially engaged Derek L. Wilson Ltd., Consulting Engineers, to undertake a study to develop an incineration system that would satisfy the original requirements of the Animal Disease and Protection Act imposed by Agriculture Canada. Agriculture Canada requires that International Waste be either incinerated or sterilized by heating to a temperature of at least 100°C for a period of not less than 30 minutes, the residue disposed of in an approved sanitary landfill site.

Due to extensive public resistance to the originally proposed solid waste incineration process, the consulting engineer suggested a thermopress system be adopted as a means of preparing the international solid waste for safe disposal at a sanitary landfill or as part of an incineration or gasification/pyrolysis system.

The Consulting Engineer and the Airlines installed a prototype facility at the Pearson International Airport. The original intent for this installation was that it function as a small scale research facility to verify that sterilization was achieved. The role of the prototype unit has since changed, due

to the closing of the Commissioner Street Incinerator and the fact that other incinerators in the province have refused to take the airport solid waste. Also the cost of disposing of the waste at the Decom facility in Quebec was excessive.

Presently airlines are treating all airside solid waste in three thermopress machines at approximately 100°C and approximately one minute retention time. This approach will continue until heat retention modules are added to satisfy the Agriculture Canada requirement of 100°C for 30 minutes. All airside airport wastes under the present waste management system are being disposed of together.

Until a detail compliance test is done on this system, all the treated waste is being stored at the Airport.

2.0 OUTLINE OF REPORT APPROACH

The scope of this report is to evaluate alternative technologies to incineration in order to determine their suitability for handling the International Solid Waste (including wastes from international aircraft, domestic aircraft and food preparation) as well as their ability to process other wastes and contaminants (i.e.: washdown glycols for de-icing, fuel spills, sanitary waste and run-off of the fire fighting effluent from the fire training area).

Three technology systems in particular are examined:

- a) Thermopress (Econoler System)
- b) Wet Oxidation (Kenox System)
- c) Destructive Distillation (Waste Distillation Technology System)

MacLaren Engineers obtained as much background information as possible on each of the systems. In light of the fact that the available information on each system is very general and not necessarily project specific, additional meetings with the representatives of each technology group were held.

For comparison purposes, the assumption was made that each system should be capable of processing 50 tonnes per day of International Solid Waste continuously 24 hours per day, 7 days per week.

System description, technical evaluation, environmental impact, conformance with applicable regulations, safety concerns and commercial aspects for each examined technology are presented hereafter under Section 3 and are intended to identify, based on

available preliminary information, the positive and negative characteristics of each system.

Of particular concern from this list of evaluation criteria are "environmental impact" and "conformance with applicable regulations".

As far as environmental impact is concerned, the system of choice must adequately address all environmental concerns to ensure that they do not constitute a danger to the general public, system operators, maintenance personnel as well as domestic livestock. These environmental concerns include interior and exterior air quality, liquid effluents, odour, noise and residues. Any solid wastes which are generated should be rendered safe and pass the leachate test as defined in Ontario's Regulation 309.

Strictly speaking, in the field of infectious control there are four categories of control for bacteria, virus, fungi, and spores, namely:

- Sterilization: o 100% free of any microbial life including bacteria, viruses, spores and fungi; e.g. - scalpel etc. used in medical operations.

- Decontamination: o Renders infectious material safe for handling and disposal. The residue could still contain some bacteria etc. but at a level not dangerous to human health.

- Disinfection: o The killing of pathogenic agents by chemical or physical means directly applied.

Sanitation: o Provides a hot water wash at about 83°C which is applicable to dishes, carts, etc.

Applicable regulations for the Pearson International Airport wastes from international aircraft come under the jurisdiction of the Animal Disease and Protection Act which requires that the wastes be either incinerated or thermally "sterilized" (heated to 100°C for at least 30 minutes).

Finally, there are several other methods of processing wastes relative to the three base schemes noted previously, namely: "other thermal", "chemical" and "physical" systems worthy of consideration. These alternatives are outlined in Section 4, "Other" Alternative Technologies. At present, these do not appear to be covered in the federal legislation having jurisdiction.

3.0 PROCESS EVALUATIONS

3.1 Thermopress (Econoler System)

3.1.1 General Description

The International Solid Waste is presently delivered by collector trucks to the research facility and discharged on a tipping floor. It should be noted that the waste is primarily arriving in ordinary plastic bags or loose. At this time, any visible large metal objects are manually removed from the waste stream and then the remaining waste is loaded to a shredder by a front-end loader. The shredded waste is discharged onto the floor where it is manually loaded onto a conveyor which feeds the thermopress feed hopper. In the thermopress, waste is compressed and macerated at a temperature in excess of 100°C for approximately one minute. The temperature and the retention time in the thermopress are dependent upon the compaction rate set point. Presently the hot briquettes produced by the thermopress are discharged onto the floor. This material will be stored on-site until a heat retention module is installed and operational. All produced briquettes will then be heat treated at 100°C for 30 minutes and tested for virus inactivation.

This system represents a pretreatment of the solid waste for either disposal at a sanitary landfill or subsequent incineration or gasification. The volume reduction of the incoming waste can be up to 90% while weight reduction will be approximately 12%.

The thermopress system is restricted to treating solid waste only, preferably with a moisture content of no more than 50%. In the Airport application waste mixing will be required prior to feeding the thermopress in order to reduce the overall moisture content (60 to 70%) associated with the waste from the flight kitchens.

In general, the solid waste preparation step is a critical element in the overall process and in our view has not been addressed adequately with the present installation.

Information on the heat retention module was not available at the time this report was prepared, consequently technical details on the overall heat treatment process intended are unknown.

A preliminary proposal indicates that the full-scale facility will incorporate four to six independent lines with a capability of processing 3000 to 4000 kg/hr of solid waste (72 to 96 tonnes/day). Based on the assumption that the system should be capable of processing 50 tonnes of solid waste, per day, the proposed facility will provide the flexibility to operate less than 24 hours per day.

The estimated Canadian content for the outlined facility will be 60%.

3.1.2 Environmental Impact

3.1.2.1 Agriculture Canada Requirements

Agriculture Canada requires that the wastes be held at a temperature of at least 100°C for period of 30 minutes. This requirement is designed to prevent the entry of specific viruses which affect livestock namely; foot and mouth disease, hog cholera and African swine fever.

MacLaren Engineers are satisfied that the Agriculture Canada guideline (100°C, 30 min.) will prevent the introduction of foreign animal diseases, however, we are concerned that the above thermal target of 100°C may not render the microorganisms, in particular spores, completely harmless to equipment operators and

the public. References 1 through 5 in the Reference List are provided to substantiate these concerns.

In order to be satisfied that the Agriculture Canada thermal requirement has rendered all microorganisms, including spores, harmless to livestock as well as the public, further investigation of the treated waste should be conducted. Key things to look for during this investigation would include:

- a) Heat transfer characteristics of the briquettes (i.e. what is the core temperature of the briquette after 30 minutes?) It must be remembered that all parts of the garbage must reach a temperature of 100°C for 30 minutes.
- b) The viability of spores before and after the heat treatment.

In light of these thermal kill concerns some consideration should be given to either increasing the temperature or extending the length of exposure time. The following section has been included to provide an indication of the thermal requirements necessary to render the microorganisms completely harmless. These requirements would only be necessary if the recommended further investigations indicated a threat to human and livestock safety still existed.

3.1.2.2 Requirements for Elimination of Bacteria, Viruses and Spores

To eliminate the possibility of bacteria, spores and viruses from infecting animals and human beings, these species must be destroyed. Simple inactivation is not sufficient for all microorganisms, some of which may become virulent with some change in their environment. These species must be destroyed.

In order to effectively destroy these microorganisms, a wet temperature of 130°C must be maintained for a period of 20 minutes. If dry heat is to be used, a temperature of 170°C must be maintained for period of 2 hours. Such sterilization parameters will guarantee that all microorganisms have been rendered harmless.

The Econoler System, although satisfying the Agriculture Canada requirements, does not satisfy this criterion. The solid wastes processed by this device are at most 30% by weight of water, hence, the heat applied would be classified as dry. Therefore, the sterilization technique as described, would be in our mind inadequate to protect the general public.

3.1.2.3 Occupational Health and Safety

Occupational Health and Safety concerns are centred around the solid waste handling aspects. In general, the concerns outlined below apply to the three base alternatives considered in this report as well as the "other" alternatives discussed in section 4.

The international wastes arrive in plastic bags ("closed containers") or loose and are stored until they can be treated. These international wastes could, on occasion, be stored for a period of one or more days, thus providing microorganisms a generous period of time to multiply in a very conducive growth environment (there being adequate food and adequate temperature).

The wastes are manually transferred to a shredder which reduces the size of the solid waste. Large objects which can not be handled by the shredder are removed manually.

There is some concern with the handling of these solid wastes which, albeit the majority have been sealed, are decomposing.

Bags which break open are subject to contamination transport by flies and vermin. This provides a route for diseases to spread. Operators should be protected from the odours generated by this waste. Adequate ventilation must be provided to protect the workers from anoxia. The handling of these bags must be done by operators who are adequately protected (i.e., gloves, work boots and masks).

The solid wastes also contain various sharp metallic objects such as knives, forks, etc., which may puncture tires, or cut feet and hands. Hence the area must be signed as a dangerous area, and the general public and airport staff should not be allowed to enter this area.

Mechanical shredders, conveyor belts and the waste storage area are subject to fires occasionally, consequently adequate fire protection should be installed. Solid wastes occasionally contain aerosols which are subject to explosion. Adequate protection is required for operators in this area due to this potential hazard.

There is concern that some particles may be sprayed at the workers, hence, adequate eye protection should be encouraged, and an emergency eye wash/shower should be installed.

Since there is a chance that various emergencies may occur in this area, a safety island should also be installed, complete with stretcher, fire blanket, and medical aids.

3.1.2.4 Public Health Concerns

Decomposing waste presents a public health concern. Although the design incorporates an enclosed tipping area, this area is not adequately protected from vermin or flies which can transmit diseases.

The enclosed area should be under negative pressure to ensure that the odours and microorganisms present in the air are not directed outside to the general public. The air removed from this space must be rendered harmless in some way. The Econoler design does not provide a means for this to be done.

3.1.2.5 Air Pollution Aspects

The decomposing waste represents a potential air pollution problem. Microorganisms carried air-borne can transmit diseases to the general public. Flies can serve as vectors of disease. The tipping floor and shredder area as well as the press and sterilizer area should be maintained at a negative pressure to minimize contamination transport. The vented air must be adequately sterilized and decontaminated. This has not been addressed in the thermopress proposal.

Noise produced by the tipping operation and the shredding operation may cause complaints, especially since the process is designed to operate continuously throughout the day.

3.1.2.6 Waste Water Problem

Presently, Cara Foods wash down the food waste from plates etc. using hot water. After dewatering, wastes with a high moisture content (typ. 60%-70% water) are mixed with the drier international waste and then treated by the thermopress. All water from the dewatering process is then sent to the sanitary sewer. This appears to be an acceptable method of disposal for Pearson International Airport, but may not be acceptable at other airports. Waste water samples should be taken to confirm conformance with local by-laws.

3.1.2.7 Residue Problem

The thermopress generates a compact briquette which can be burned or possibly disposed of at a landfill. Such briquettes would be sterilized according to a procedure suggested by Agriculture Canada. The briquettes are to be heated to a temperature of 100°C for a period of 30 minutes.

As previously discussed, MacLaren Engineers is concerned that this level of treatment may not provide adequate sterilization for the following reasons:

- o the temperature of 100°C is inadequate to ensure sterilization of the briquettes (i.e. will not completely eliminate spores which may regenerate); the briquettes are less than 30% moisture; hence, a temperature of 170°C is required for a period of two hours;
- o there is no way to monitor the temperature of the briquette at its core to ensure that adequate sterilization has been achieved (Further research is needed to determine the heat characteristics of the materials generated by the thermopress);

MacLaren Engineers is also concerned that the briquettes may not pass the leachate test because of the amount of metal in the waste; i.e., the briquettes might be considered a hazardous waste, however, this is unlikely considering the waste sources (non-industrial).

3.1.2.8 Odour Problem

Decomposing garbage produces an odour problem. This problem may be minimized by maintaining a negative pressure in the enclosed tipping and shredding area. The air removed from this space must

be rendered harmless in some manner. This may involve the use of a disinfectant, or scrubbing and reusing the air in some other process. The thermopress option does not address this problem adequately, consequently this aspect of the system warrants further investigation.

3.1.3 Commercial Aspects

A preliminary capital cost for a full-scale facility including four thermopress/heat retention module lines complete with shredders and conveyors, equipment building (with a floor area of approximately 2000 m²), all services and laboratory is \$6,140,000. This price includes a front-end loader, odour scrubber, and a briquette transportation system from the heat retention module to the storage area, however, it does not include for a waste water treatment system if necessary.

Preliminary annual operating and maintenance costs based on a two shift operation are approximately \$485,000.

Disposal cost of the processed waste is estimated to be \$1,200,000. based on a unit cost of \$75./tonne and 50 TPD waste input.

Total labour force without maintenance crew, based on a two shift operation is estimated to be 7.

The proposed system does not have any type of energy recovery which will have impact on overall economics.

The life span for a permanent facility is expected to be minimum 20 years.

Preliminary information from the authorities indicate that the approval for such facility, no matter what technology is used,

can be anywhere from a few months to two years if the complete Environmental Assessment Review Process (ERP) is required. Keeping in mind general public concerns, political sensitivity to the waste management issue and preliminary indication that the requirement for ERP might become mandatory, it is our feeling that the approval process will be lengthy.

Excluding the approval process, the estimated implementation period for this technology from the start of engineering to equipment start-up is one year.

3.1.4 Related Experience

The Econoler system is specially designed for this application as part of the research program and therefore has no track record.

3.2 WET OXIDATION (KENOX PROCESS)

3.2.1 General Description

The Kenox wet oxidation system utilizes reactors where organic compounds in the waste stream are oxidized in the presence of oxygen. Both solid and liquid wastes are fed together in slurry form to a pre-heat exchanger (utilizing reactor effluent) and then on to a series of reactors. Oxygen is provided to the reactors in the form of air via a compressor. Oxidation then takes place in the reactors at temperatures in the order of 230-240°C and pressure of approximately 4500 kPa, with a total residence time of 40 minutes. Reactor effluent is first passed through the pre-heat exchanger and then through a second heat exchanger to provide further cooling. City water is required for this cooling step and as a consequence of the heat exchange, hot water is produced. The effluent is then passed through a separator where the entrained gases are separated from the liquid and solids. The liquid and solids are sent to a press where the solids are filtered (to be sent to landfill) and the liquid is recycled and/or delivered to an aerobic biological polishing system. The gases are fed to the aerobic polishing system where they are scrubbed. Final effluent from the aerobic system is then discharged to the municipal sewer system.

The Kenox system will readily treat the basic and peripheral wastes as outlined in section 2.0 Outline of Report Approach. Solid waste must be mixed with the liquid waste streams and/or recycled water to form a slurry. The slurry is fed to the reactors via a grinder pump (which reduces particle sizes to the order of 1/8"). The feed stock must not exceed the limitations of the grinder pump, consequently a shredder will be required. A tipping floor would be necessary to receive the waste and remove any large metallic objects which could not be shredded. The waste preparation step, i.e., receiving solid waste, waste

storage, separating unshreddable objects, shredding, and preparing the reactor feed slurry with liquid waste streams and/or recycled water has not been addressed at length in the Kenox report and warrants further investigation.

In accordance with the Animal Disease and Protection Act, solid waste must be contained in closed containers and subsequently incinerated or sterilized. Since the Kenox waste treatment system will require opening of these containers to allow removal of unshreddable objects, a potential contamination problem is created which has not been addressed and also warrants further investigation. This is a common problem with all three processes being evaluated.

Start-up of a "cold" reactor would take approximately one hour, therefore extensive storage space requirements (over and above that provided by the tipping floor) would not be required while waiting for the system to be on line. This assumes the incoming waste quantities do not exceed the design rating of the Kenox system (50 TPD).

3.2.2 Environmental Impact

3.2.2.1 Agriculture Canada Requirements

(See section 3.1.2.1 for a general discussion.)

3.2.2.2 Requirements for Elimination of Bacteria, Viruses and Spores

This process adequately sterilizes the wastes by maintaining a temperature of at least 200°C for a period of 40 minutes.

3.2.2.3 Occupational Health and Safety

In addition to concerns expressed in Section 3.1.2.3 above, there are further concerns with the Wet Oxidation System. The system can be considered a pressure vessel, and a stationary engineer may be required to operate the system.

3.2.2.4 Public Health Concerns

(See Section 3.1.2.4)

3.2.2.5 Air Pollution Aspects

(See Section 3.1.2.5)

3.2.2.6 Waste Water Problem

The system as designed produces a liquid effluent which is unsuitable for discharge to a sanitary sewer without subsequent biological treatment suggested by the supplier. MacLaren Engineers are concerned that the biological treatment system might not be supplied with adequate food for long periods of time, and this can cause shock problems.

3.2.2.7 Residue Problem

The Wet Oxidation System produces a char which is composed primarily of carbon. This waste can probably be landfilled since most magnetic material will have been removed by magnetic separators prior to wet oxidation.

3.2.2.8 Odour Problem

The entire plant should be maintained under negative pressure to ensure that odours and microorganisms do not escape to the

environs. This provision has not been addressed by the supplier as no information concerning the equipment building was provided. This air is treated in the wet oxidation reactor, while off-gases are scrubbed in the process water prior to wet oxidation, hence, the odours and microorganisms should be adequately treated by this system.

3.2.3 Commercial Aspects

Kenox representatives have indicated a capital cost estimate for a system capable of treating all wastes described in section 2. Outline of Report Approach, of \$7,000,000. This price includes for an effluent biological polishing system, however, does not include an equipment building and its associated services.

Annual Operation and Maintenance costs were reported to be approximately \$876,000. This figure includes for a total labour force of nine personnel working over three shifts.

Residue disposal cost is estimated to be \$120,000. per annum.

As mentioned previously, hot water is a product of one of the heat exchanger steps. Approximately 280 m³/hr is required for the heat exchange and consequently 280 m³/hr of 70°C water (quantity and temperature can be varied) is produced. This may be a useful energy source if the airport has use for hot water. However, if there is no use for the water or it is not sufficiently cost effective to warrant its use, the heat rejection from the hot water may result in additional costs (ex. for a cooling tower) not presently accounted for in the cost estimates.

3.2.4 Related Experience

To date the Kenox system is operating at only one facility, a drum cleaning plant in Mississauga. This facility represents the first Kenox installation. The waste being treated is a complex and variable liquid waste stream and apparently the results of the 2 1/2 years of operation have been positive. The Kenox system has not been utilized for solid waste applications to date, however, wet air oxidation systems of similar design have been used for applications involving solid waste.

3.3 Destructive Distillation (Waste Distillation Technology Inc. Process)

3.3.1 General Description

The Waste Distillation Technology (WDT) system converts municipal waste into carbon char and volatile gases using a process known as destructive distillation. Solid waste is received on a tipping floor and any large unshreddable objects are manually removed. The remainder of the waste is fed to a shredder and then to a dryer. From the dryer the waste is then fed at a controlled rate to a distillator where destructive distillation takes place. In the distillator the waste is slowly tumbled in a rotating retort tube at a temperature of approximately 650°C for approximately 15 minutes. The distillator is an oxygen free environment thus not allowing any combustion to take place. Gases which are produced in the distillator are used to heat the distillator itself and any excess gas (typically about 85% of the gas manufactured in the distillator) is available as a fuel source. The sterile char that is produced contains approximately 40-50% pure carbon which may be of commercial value. This char represents about 10% by volume and 25% by weight of the original feed stock.

The WDT Distillator is a modular unit with each module having a capacity of 50 TPD. To ensure 100% availability for the airport application (50 TPD), two modular distillators would be proposed thus having a total capacity of 100 TPD.

A two module plant would occupy approximately 1,000 m² of land area in a two storey building (excluding truck turn around access).

Municipal solid waste can be readily treated in the distillator, however, current literature from WDT does not address the

treatment of liquid wastes such as those described in Section 2 Outline of Report Approach. More detailed information of the liquid waste streams will be necessary for WDT representatives to assess the distillator's capability of treating liquid wastes.

The waste preparation step (i.e. receiving, storage, removal of unshredable objects, shredding, handling liquid waste streams, etc.) has not been addressed in detail by WDT representatives and warrants further review.

3.3.2 Environmental Impact

3.3.2.1 Agriculture Canada Requirements

(See Section 3.1.2.1 for discussion.)

3.3.2.2 Requirements for Elimination of Bacteria, Viruses and Spores

This process exposes the solid wastes to temperatures of 620°C for a period of 15 minutes which should adequately sterilize the material.

3.3.2.3 Occupational Health and Safety

There are some concerns with the Destructive Distillation System in addition to those expressed in Section 3.1.2.3. The system can be considered a low pressure vessel, boiler, and furnace. A stationary engineer will be required to operate the system.

3.3.2.4 Public Health Concerns

(See Section 3.1.2.4)

3.3.2.5 Air Pollution Aspects

This process treats the waste in two stages. The first stage involves destructive distillation of the solids wastes in the absence of oxygen to produce a low calorific value gas. This gas is then burned to produce heat to generate either steam or electricity. Problems may be found in the types of combustion products generated by this latter stage. Further research into the compounds produced from combustion of the gas are required to ascertain the acceptability of this process.

3.3.2.6 Waste Water Problem

(See Section 3.1.2.6)

3.3.2.7 Residue Problem

The solids generated are at a temperature of about 600°C when rejected by the furnace. This residue is misted with water to discourage oxidation, combustion, and lower its temperature. It should be noted that this residue may be a hazardous waste classified as combustible under the Transportation of Dangerous Goods Act and Regulation 309.

3.3.2.8 Odour Problem

(See Section 2.1.2.8)

3.3.3 Commercial Aspects

The consultants to WDT namely Mertex Consultants Inc., have indicated a capital cost price estimate for the Pearson Airport application of \$10,000,000. which includes a complete system capable of processing 90 TPD (two distillators and dryers and one boiler are included) of solid waste. The price excludes any

energy recovery equipment (with the exception of the boiler) and includes an equipment building.

Annual operation and maintenance costs have been reported to be \$1,325,000, with a labour crew of 20 (maximum) required.

Residue disposal cost is estimated to be \$340,000. per annum.

Energy recovery is present in the form of a low calorific value (typically 7450 kJ/m³) fuel gas. Gas production rates would be in the order of 71,000 m³/d. Since this is a fuel gas of relatively low calorific value, there are concerns with its combustion and the quality of the combustion products, possibly rendering the energy recovery aspect more problematic than advantageous.

3.3.4 Related Experience

The WDT system to date has one related application, namely a detailed testing program at Marcal Paper Mills Inc. of New Jersey. The U.S. Dept. of Energy conducted extensive testing and evaluation of a 50 ton (45 tonne) per day waste distillator at the Marcal Paper Mills plant utilizing a residential - commercial waste. A summary report entitled "Evaluation and Test Program of a 50-Ton Per Day Waste Distillator" (U.S. Dept. of Energy-DOE/CE/15126-T4) is available and general conclusions are as follows:

- o a significant reduction in volume and weight of the MSW feed stock was achieved;
- o process produced a significant amount of useful energy;

- o conversion to energy with minimum air, ground and water pollution should apply to almost any location where a facility of this type is contemplated;
- o consideration must be given to unique local factors such as extreme climatic conditions or lack of energy users which could influence economic viability.

3.4 SUMMARY TABLE

PROCESS CHARACTERISTICS	THERMOPRESS ECONOLER SYSTEM	WET OXIDATION KENOX SYSTEM	DISTILLATION WDT SYSTEM	REMARKS
Type of Waste Handling	Solid Waste Only	Solid and Liquid Waste	Solid and Possibly Some Liquid	Kenox system suitable for all waste.
Waste Storage	Tipping Floor	Tipping Floor	Tipping Floor	Similar
Solid Waste Preparation	Shredding	Shredding	Shredding	More attention required for all systems.
Agriculture Canada Requirements	100°C for 30 min.	100°C for 30 min.	100°C for 30 min.	
Process Temperature Retention Time	100°C 30 min.	240°C for 40 min.	620°C for 15 min.	Econoler least likely to eliminate all bacteria, viruses and spores.
Requirements for Elimination of bacteria, viruses and spores.	170°C for 120 min.	130°C for 20 min.	250°C for 15 min.	See discussion in Section 3.1.2.1.
Safety Concerns	Health, Fire, Explosion	Health, Fire, Explosion	Health, Fire, Explosion	Similar
Air Pollution Problem	Present	Present	Present	WDT system has higher air pollution.
Waste Water Problem	Present	Treated	Present	Kenox system treats the waste water.
Residue Problem	Present	Sterilized char	Sterilized char at 620° C	Econoler residue may still be contaminated.
Odour Problem	Present	Present	Present	Kenox system has fewest problems of the three.
Installed System Capacity	72-95 tonnes/d	70 tonnes/d	90 tonnes/d	
Number of Units	4-6 Units	4 Units	2 Units	
Capital Cost	\$6,143,000.	\$7,000,000.	\$10,000,000.	See text for details.
O & M Cost Per Year	\$ 485,000.	\$ 875,000.	\$ 1,300,000.	
Residue Disposal Cost/year @ \$75/tonne	\$1,200,000.	\$ 140,000.	\$ 340,000.	
Waste Reduction by Weight	12%	90%	75%	
Energy Recovery	None	280 m ³ /hr @ 70°C (hot water)	9-11,000 kg/hr steam	Econoler system provides no energy recovery.
Number of Support Staff	7 (two shifts)	9 (three shifts)	20 (three shifts)	WDT system includes dedicated maintenance staff.
System Availability	100%	95%	100%	
Building Size	2,000 m ² ±	1,100 m ²	1,000 m ²	Kenox require additional 400 m ² ± for Aerobic System
Workability	Unproven	Unproven	Unproven	Typically 5 yrs operation required to make accurate assessment.
Reliability	Unproven	Unproven	Unproven	Typically 5 yrs operation required to make accurate assessment.
Expected Life Span	20 Years	20 Years	20 Years	Unproven
Track Record	None	Drum Plant Mississauga (2½ years) liquid waste only.	Marcal Paper Mill - New Jersey (2 years)	WDT system has a two year record of processing Municipal Solid Waste.
Canadian Content	60%	80%	N/A	

4.0 "OTHER" ALTERNATIVE TECHNOLOGIES

4.1 General

Under this section, it is proposed to review "other" alternatives to the three base infectious waste processing technologies previously investigated.

4.2 Listing of "Other" Alternative Technologies

a) Infectious Waste Processing Alternatives

thermal methods

- . autoclaving
- . "other" wet oxidation
(Zimpro, Vertech, etc.)
- . "other" gasification/
pyrolysis (PKA-Keiner,
plasma-arc, etc.)

chemical methods

- . shredding/disinfection
(hypochlorite)
- . lime disinfection
- . strong oxidizers
(ozone, hydrogen
peroxide, etc.)
- . toxic substances
(poisons)

physical methods

- . irradiation
- . ultra-violet
- . UV-ozone

b) Treatment Location Alternatives

- . on-site: individual processing at source
- . off-site: special containerization at source; then
refrigerated trucking to a central processing
facility.

c) Combination Processing

- . the possibility of utilizing two (or more) technologies to best suit an overall waste stream.

4.3 Review of "Other Thermal" Processing Methods

4.3.1 Autoclaving

4.3.1.1 General

This method of infectious control has been historically utilized for hospital equipment sterilization and for biomedical waste decontamination. The former category is related to individual hospitals, while the latter may apply to either individual or common ones. An example of a common facility approaching the Pearson size is the high capacity Bingham/BFI processing facility in Los Angeles CA, as described hereafter.

Virtually all North American autoclaving facilities are of the batch-processing type, and this category will be reviewed for suitability at Pearson. Note that a continuous-processing type has reportedly been developed in Europe, but this will not be reviewed under this report due to lack of details.

It is proposed to review the technology of autoclaving in relation to the biomedical waste field where, like the airport application, infectious wastes are a key issue.

4.3.1.2 Practice of Autoclaving (Biomedical)

. Biomedical Waste Types

Typical infectious biomedical wastes suitable for processing by autoclaving are listed as follows:

- isolation ward wastes
- cultures and stocks of infectious agents
- sharps
- blood and urine samples (although odours are of concern)

Wastes not suitable for autoclaving include:

- anatomical, animal carcasses, meat chunks, etc.
- organics which tend to volatilize (explosion risk)

. Processing

In autoclaves, the waste is subjected to steam temperature and pressure treatment. The important parameters which determine the effectiveness of decontamination are:

- temperature, time of exposure, and moisture content
- in USA, the EPA requires 254°F for 40 min.
- in Ontario, the MOH calls for 275°F over 60 min, requiring saturated steam which is 97% condensate-free. (The longer retention provides for laboratory wastes).

Monitoring

The temperature and time of exposure, developed in "qualifying tests" for a particular waste stream, are confirmed using a spore test. The procedure of such a test involves:

- seeding a "challenge load" of waste with a biological indicator, typically a resistant spore.
- subjecting it to heat treatment
- analysing the processed waste for left-over spores.

According to government regulations, this procedure set out by CSA must be repeated on a periodic basis, e.g.:

- once per week for steam autoclaves
- once per load for ethylene-oxide autoclaves

Regulatory jurisdictions involved with autoclaving comprise:

- MOH for medical suitability
- MOE for environmental matters
- Consumer and Commercial Relations for occupational health and safety (OHS Act)
- Ministry of Labour for unfired pressure vessels.

4.3.1.3 Representative Low-Capacity Autoclave

The "Amsco" Retort System processes up to 6 tons/day of infectious wastes, and is characterized as follows:

- not a sterilizer, but a "retort."
- 5' diameter by 12' long
- developed by Baker in California in 1983
- capacity up to 50 bags/hr @ 10 lb/bag = 500 lb/hr, or 2 tons per shift (8 hr/day), or 6 tons per day (24 hr/day)
- \$130,000 approx. capital cost (excluding building and associated services)
- \$68,000 approx. annual O & M cost
- no Canadian installation yet
- compaction is optional, and separately provided at additional cost

4.3.1.4 Representative High-Capacity Autoclave

The latest Bingham/BFI autoclaving facility in Los Angeles California is the most recent of four facilities in Southern California, and has been in operation for roughly two years. There is only one autoclave in this plant as there are virtually no mechanical moving parts in comparison to an incinerator or shredder, however, space is provided for a future second unit. Two 150 HP steam boilers generate steam for the autoclave at 80 psi/325°F. The autoclave itself is 9' diameter by 29' long, and

has a capacity of 3500 lbs/hr, or 14 tons/shift (8 hr/day) or 40 tons/day (24 hr/day).

Reusable infectious waste containers of polypropylene are placed on mechanical unloaders for dumping into three large carts which are then moved into the autoclave on rails. The entry door moves laterally on an overhead frame, and is then securely bolted in place before applying the steam. After processing, the three carts are moved to a mechanized cart unloader for discharging into a residue compactor which in turn charges a large roll-off container which is then transported to the landfills. In the meantime, empty waste containers are conveyed through a washing station, to a storage area for recycle via the wastes collection trucks.

Capital cost for this facility was in the order of \$2,300,000. and included on autoclave, two steam boilers (150 hp each), auxiliary equipment (including conveyor, crane, special ventilation, steam apparatus, etc.) scale and scale house, 20,000 s.f. building, yard work.

Operation and maintenance costs were approximately \$500,000./year including residue hauling and landfill fee.

4.3.1.5 Summary

Alternative thermal processing by high-capacity autoclave should be considered for any larger infectious-waste processing project because of inherent simplicity, proven experience on biomedical wastes, and reasonable cost.

On the other hand, there are drawbacks of restriction on waste types suitable for autoclaving, odour emissions during unloading, awkward (batch) operation, and perhaps explosion risks from igniting volatile wastes.

In considering the pros and cons, we feel that odour potential and waste restriction outweigh the autoclave's merits, so it does not appear to be a promising alternative for Pearson.

4.3.2 Other Wet Oxidation Units

4.3.2.1 Zimpro

This is the historic manufacturer in the commercialization of wet oxidation however, to the best of our knowledge, the supplier has no particular experience in the processing of slurrified refuse-but rather has concentrated on the thermal sludges, (thermal conditioning); high-strength wastewater treatment, etc. in the municipal and industrial fields. It is noted that Zimpro utilizes a percolating reactor which is reportedly less capable than the Kenox mechanical reactor in terms of forming the initial solution or slurry, and contacting the liquid and gas constituents. In addition, their capital and operating costs are somewhat high; as are their operating temperatures and pressures.

Thus, the Zimpro unit appears less suitable to Pearson than Kenox.

4.3.2.2 Vertech/Air Products and Chemicals

This is the latest entry into the wet oxidation business, and offers a deep-shaft variation involving a 5-mile deep U-tube in the ground. This extreme depth is utilized to generate the very high reactor pressures required for wet oxidation of sludge to ash residue and liquid effluent. Notwithstanding the novel approach, this unit appears to have some significant drawbacks including the following:

- lack of operating experience, except for a demonstration unit in Colorado.
- could be susceptible to corrosion as stainless steel is reportedly utilized in the reactor instead of titanium.
- difficulty of clean-out under fouling circumstances
- fracture susceptibility from geological shifts in the earth's crust.

Notwithstanding the above drawbacks, it is noted that Vertech Products Canada was recently selected by Windsor engineers for processing sludge from their West Windsor and Little River sewage treatment plants. Also, a competitive system called "Veridine" has been selected for Houston, Texas.

Again, this unit appears somewhat less suitable for Pearson than Kenox.

4.3.3 Other Gasification/Pyrolysis Units

4.3.3.1 General

Gasification (pyrolysis) is an organic distillation process in which the hydrocarbon material in refuse is converted into gas, char, and oil (tar) fractions. This conversion process is brought about by heating the refuse to 600 to 1000°C either in a low-oxygen environment (gasification) or in an oxygen-free regime (pyrolysis). Each of the three products can be used for firing conventional fossil-fueled boilers or engines, supplementing natural gas in pipelines (after enrichment), or replacing feedstock in a petrochemical plant.

4.3.3.2 Historical Practice

In the 1970's, the old practice of gasification (pyrolysis) was reactivated by certain groups in light of skyrocketing fuel prices, and an increasing environmental ethic regarding refuse disposal. Some notable developments are outlined as follows:

"Ancdo-Torrax" Pyrolysis - slagging gasification of raw refuse using cycling "stove" heat-exchangers to store heat for preheating the air feed, a shaft furnace operating at 1400°C, and a waste heat boiler. There were installations in Luxembourg, France, and Germany, but the technology eventually dissipated after repeated problems with physical workability and inadequate economic return.

"Union Carbide" Purox - slagging gasification of shredded refuse using gaseous oxygen fed to a shaft furnace operating at 1650°C, followed by gas clean-up (scrubber, precipitator, condenser) for producing a higher quality fuel gas at 350 Btu/cf (about one-third that of natural gas). This process showed great promise, but Union Carbide were hesitant to proceed commercially because

of workability and economic impediments. The rights may have been sold to a Japanese group.

"Garrett Research" - non-slugging gasification of shredded refuse using a flash pyrolysis process to provide a dominant product mix of oil and char. This did not pass the demonstration phase.

"Syngas Recycling Corp." - an offshoot process from development work at the U.S. Bureau of Mines and Batelle Lab involving hydro-gasification which emphasized the production of a high quality gas suitable for supplementing natural gas pipeline distribution. This was promoted to the City of Toronto but did not gain any commercial momentum.

"Plasma-Arc Pyrolysis" - a slagging gasification of shredded refuse using an electric plasma-arc operating at 8300°C to heat a reactor vessel to about 1200°C, followed by gas clean-up for producing a higher quality fuel gas at roughly 360 Btu/cf. In the '70's, a demonstration unit was operated by "Resource Recovery Corp" Raleigh, NC, and the scheme was promoted by "Resorption Canada," Ottawa, Ontario, in Canada. Current demonstrations on the effectiveness of hazardous waste destruction are being carried out by the Ontario Research Foundation for Ontario MTT, and by Dr. T. Barton at RMC Kingston for the U.S. EPA.

4.3.3.3 Recent Practice

"PKA - Keiner," Munich Germany - non-slugging gasification of prepared refuse (shredded and granulated) in a rotary distillation kiln for the production of pyrolysis gas, followed by a cracking reactor for gas enrichment to 167 Btu/cf and dioxin destruction at 1100°C to 1400°C, followed by clean-up and cooling prior to utilization.

A feature claimed is that the refuse sorting and granulating plant can be centralized, while the pyrolysis modules can be decentralized to the locations of gas users (for heat or power)- with trucking of fuel granules in between.

In Germany, a demonstration unit rated 8 tph of raw refuse (smallest practicable) has been in operation at Aalen-Unterkochen, since December 1983.

A representative equipment cost for a 600 tpd facility comprising sorting, granule, and pyrolysis plants is \$30 million (January 1986), i.e. excluding installation, civil works, etc.. The total facility cost is claimed to be roughly similar to that of an EFW mass burning incineration plant. Note that the cost for gas utilization equipment would be \$0.5 million for 6 retrofit gas burners rated 4300 kW each, or \$8.0 million for 18 engine-generator sets rated 330 kW each.

Rossi Process, Italy/Duomo Import, Toronto - a non-slugging gasification promoted to Ontario Hydro and others as a fuel supplement for power boilers. A processing line rated 100 tpd of dry refuse would have a capital cost of \$4 million (1981) and an operating cost of \$1.38 million/year. The revenue claimed would be as follows:

oil	-	52 500 barrels/yr @ \$30/barrel	=	\$1.58 million/yr
char	-	21 000 tons/yr @ \$20/ton	=	.42 "
gas	-	700 000 kg/yr - all recycled	=	0
TOTAL			=	\$2.0 million/yr

The simple payback period was claimed to be about 10 years.

Dynecology Harrison NY (Simplex) - a slagging gasification of fabricated biomass briquettes comprising shredded refuse, crushed bituminous coal, sewage sludge etc. fired by oxygen at the

reactor bottom to produce an enriched fuel gas of 330 to 440 Btu/cf and a vitreous slag. Temperatures are in the order of 1100°C at the bottom, and 425°C to 870°C at the top. Development has included pilot plants of 2 tpd and 25 tpd ratings, with 300 tpd as a potential follow-on.

EFW Systems, Markham - non-slagging pyrolysis of shredded and dried refuse on a special SS mesh conveyor within a reactor having natural gas fired heaters. This appears similar to previous units by "Pyrosol" and "Brenner." The intent is to produce a high quality syngas for fuelling gas engines, i.e. 350 Btu/ cf target. The promotional consortium includes Atlas Polar (gas engines), Bennett and Wright (contracting), and others. A 35 tpd demonstration plant was operated on a "Miller Paving" site in Markham and viewed by our staff in late 1985. EFW advise that attempts had been made to shift the conversion reaction away from hydrogen and towards methane (more suitable for conventional gas engines), but this was found to be difficult.

Plasma-Arc Pyrolysis - following on from the original prototype installation described previously under Item 2, here is the present status of this promising and rapidly developing field:

- i) Pyrolysis Systems Inc., Welland - organized in 1984 by Dr. T. Barton, a leading investigator in this field, Pyrolysis Systems have been involved with the development of a transportable PCB destruction with funding from EPA, Environment Canada, and Ontario Ministry of the Environment. This is a 500 kW plasma unit manufactured by Westinghouse Pittsburgh. Another primary interest was the conversion of coal slurry (or other biomass) to a methanol synthetic fuel for Gulf Oil.

- ii) Plasma Energy Corp/Resorption Canada - this group submitted a proposal to Ontario Ministry of Energy, in conjunction with Ontario Hydro's Research Division and Oboe Engineering, Ottawa for a 7.2 tpd (600 lb/hr) demonstration plasma unit for converting raw refuse to syngas fuel for power boilers.
- iii) SKF Steel, Sweden - has developed three plasma-arc systems as follows:
 - . "Plasma-waste:" for gasification of industrial and household refuse
 - . "Plasma-dust:" for metal recovery and heat recovery from refuse, involving metals from various metal-oxides.
 - . "Plasma-red:" for combined iron production and district heating.
- iv) Other Plasma-Arc Units
 - "W. J. Huber," U.S.A: for PCB destruction
 - South Africa Union Steel Co.: a sponge iron plant employing plasma-arc processing.

4.3.3.4 Evaluation

In evaluating the suitability of gasification/pyrolysis against other energy-from-waste options, the following perspective is presented:

PRO

- . virtually no air emissions, in a primary sense (although there are secondary ones from firing boilers, engines, etc. and with the product gas).
- . no tall stack.
- . energy output is in a desirable gaseous form, featuring clean handling and utilization flexibility - as fuel gas, pipeline gas supplement or chemical plant feedstock.
- . the product gas can be readily utilized in existing gas-fired boilers, or in new gas-fuelled engines.
- . the product gas can be readily scrubbed before utilization.
- . virtually no excess air ramifications with attendant NOx emissions.
- . plant concept lends itself

CON

- . safety hazard: susceptible to explosions because an explosive gas is produced within the pyrolysis vessel.
- . hammermills are prone to operating difficulties.
- . operations record: generally poor as evidenced by explosions and other difficulties at Baltimore, Duluth, etc., i.e. similar pyrolysis/gasification plants.
- . workability: not good due, in part, to the sensitivity of heat transfer between refuse and hot gases in the reactor.
- . pretreatment of refuse: shredding and drying are generally required due to the wide variability of refuse in size, material, and moisture content. These increase mechanical complexity and safety risk, together with capital and operating costs.

to a modular design (i.e. better than a mass-burning incineration plant).

- . economics: tend to be relatively expensive.
- . the restricted distance that "low Btu" product gas can be piped is limited.

4.3.3.5 Summary

In weighing the pros and cons of gasification/pyrolysis, we feel that the "cons" still dominate, so the use of the gasification/pyrolysis option is not generally suitable at this time. However, there are continuing developments which may redress the balance, and the promising ones will be carefully examined in future. For example, plasma-arc pyrolysis technology has good potential, and is already being utilized effectively for special cases such as PCB destruction and coal conversion. Also, the best of the more conventional gasification units appears to be the PKA-Keiner unit because of its proven workability and well developed components.

In our view, gasification/pyrolysis represents an attractive proposition for Pearson Airport, however it may not be sufficiently advanced to utilize it at this time.

4.4 Chemical Processing Methods

4.4.1 Shredding/Disinfection - Using Hypochlorite

4.4.1.1 Description

The following description of "shredding/disinfection" equipment summarizes the performance and features offered by the leading Supplier, Medical SafeTec, Indianapolis - together with an estimate of related costs. Note that our staff made an appraisal of their demonstration facility at Indianapolis Methodist Hospital in January 1987.

Unit Performance

. equip - model	"Medical SafeTec" Wastemaster Series 12 500
. type of waste	infectious biomedical
. unit operating rate:	
- nominal	1.0 ton/hr (harder materials)
- maximum	1.5 ton/hr (softer materials)
. unit operating time	1 hr/day typ, 2 hr/day max.
. unit capacity	1 ton/day nominal; or 35 ton/mos, or 250 tpy (260 days/yr).
. servicing frequency	after 100 000 lbs. throughput (<u>or</u> 50 hrs. operation), - replace hammers - 2 hrs. for 1 man (claimed by Supplier)

Waste Material Considerations

. Acceptable:

- Glass, sharps, plastics, textiles, etc. are normal and acceptable.

. Unacceptable:

- Large metal items must be separated out. However, the equipment reportedly handles minor surgical utensils such as scalpels, clamps, etc.
- Large organic wastes such as pathogenic, animal carcasses, chunks of meat etc. are difficult to handle.

Pathogen Destruction

- Pathogens (bacteria and viruses) are claimed to be destroyed after 3 minutes contact time in hypochlorite solution. It seems that certain spores might not be destroyed due to 1 hour contact time required, however, these are claimed to be harmless.
- Equipment is designed for the required retention in the main processing unit, however additional contact time may be achieved in the residue disposal bin.
- The effectiveness of total pathogen destruction still has to be positively confirmed by Ontario MOE which, by the way, strongly supports this unit.

Wastewater Effluent

- Quality assurance can be achieved by monitoring the effluent's chlorine residual in a contact tank. When pathogen destruction must be confirmed, a larger effluent holding tank might be required for longer contact time. This confirmation is not typical because of the very high chlorine residual carried through the system, i.e. 500 to 2000 mg/L.
- For each system, up to 1800 Usqph of wastewater at roughly 500 ppm of chlorine equivalent is discharged to the sewer over the operating duration (1 to 2 hours per day).
- Some municipalities advise that the wastewater's maximum effluent chlorine concentration should be similar to that from a swimming pool (roughly 5 mg/L), while others less demanding - accepting the disinfection as a benefit. Reduced concentration can be achieved by dilution with the overall sewage flow from the institution served. Alternatively, concentrated wastewater may be retained in a storage tank, and bled into the municipal sewer over a larger period of time (up to 24 hrs/day). Finally, chemical dechlorination can be accomplished by adding either sulphur dioxide solution or sodium thiosulphate tablets to the wastewater effluent stream.

Ventilation System

- Each equipment package is kept under negative pressure by a dedicated ventilation air system, thereby minimizing the exposure risk of microbiological aerosols to operators and other personnel.

- Ventilation air is exhausted from the equipment through high-efficiency particulate air (HEPA) filters which entrap bacteria.

System Components

- . Feed Conveyor: inclined belt type
- . Shredder: first-stage slow-speed shear shredder having two intermeshing rotors with hardened tips; 7 and 5 HP rating.
- . Hammermill
 - The second-stage is a high-speed hammermill, driven by a motor rated 125 BHP at 3550 rpm.
 - Impacting of solids before passage through a discharge grate reduces solids size and increases exposed surface area, for more effective disinfection.
 - Particle size is established by type of feed material (paper, plastic, glass) and by size of cylindrical discharge grate opening (1/2 to 3/4" - the final sizes ranging from sand-like for glass to about 1/2" for plastic chips.
 - Major components are of ordinary steel construction.
 - Rotor has to be removed periodically for replacing of hammers, and rebuilding (or replacing) the cylindrical grate.

Residue Conveyor

- "slotted" drain openings in drain special residue conveyor system of plastic construction.
- dumps into a special cart with small drain holes in bottom.
- up to 80% solids in final residue.

Disinfection System

- Use commercial bleach, delivered in bulk at 12% solution strength, in larger installations. Note that electrolytically-generated hypochlorite solution is often utilized in smaller installations.
- Hypochlorite (NaOCl) consumption: 55 USgal/cu.yd. of biomedical waste typical, based on 12% solution strength.
- Hypochlorite solution from bulk storage is diluted to provide a feed rate of 1800 gph at 2000 mg/L.

4.4.1.2 Summary

The shredding/disinfection system is seen to be a generally desirable system from an environmental point of view as there are virtually no air emissions of concern. It is particularly effective in disposing of fluids such as blood, urine samples, etc. The cost of disposal is reasonable.

However, it does not appear promising for Pearson based on the following:

- restricted to infectious wastes only (in comparison to both infectious and general wastes).
- low experience record in actual service, although a demonstration project is intended for a central facility serving Toronto's core hospitals.
- low processing capacity
- concern over the requirement for extensive regular periodic maintenance on a long-term basis.

4.4.2 Lime Disinfection

In the field of sewage sludge disposal, lime can be mixed with sewage sludge in appropriate proportions to raise the pH to roughly 12 thereby destroying all microbiologic life and making the sludge safer for landfill disposal, i.e. devoid of pathogenic bacteria.

We believe that this approach has not yet been tried commercially on infectious solid wastes - probably because of the difficulty of effectively mixing lime powder with relatively dry refuse. However, the possibility of dosing a slurrified waste might appear to be conceptually possible.

Although this technology is generally attractive because of its relative simplicity it is not sufficiently advanced for real consideration at Pearson Airport.

4.4.3 Strong Oxidizers

Again, the use of strong oxidizers such as ozone, hydrogen peroxide etc. is conceptually possible as alternatives to chlorine or hypochlorite solutions.

4.4.4 Toxic Chemicals (Poisons)

These are conceptually possible but, in our view, do not represent a realistic alternative for Pearson Airport.

4.5 Physical Processing Methods

4.5.1 Irradiation

4.5.1.1 General

Irradiation offers efficient, economical processing, without chemicals or heat, for a wide variety of industrial, scientific and medical applications. Once associated primarily with cancer therapy, radiation is now used for tasks ranging from the detoxification of chemical wastes to modifying gemstone colour.

Sources of radiation range from the sun to the microwave oven. Radiation sources for commercial irradiation include ultraviolet, radioactive isotopes, linear accelerators, cyclotrons, and microwave generators. The two most commonly used for industrial processing are radioisotopes and electron beam accelerators.

The dominant radioisotope is Cobalt 60, a radioactive substance created in nuclear reactors. This emits penetrating gamma radiation, and continues to do so at a decreasing rate over a half life of 5.2 years. It must be replenished to maintain a given processing power. It must be shielded, handled, and transported carefully; and disposed of ultimately in a nuclear waste site. Its penetrating gamma radiation is used to excite electrons in the material being processed, thereby indirectly causing the desired decontamination effect.

The electron beam accelerator is a machine which converts electricity into a beam of electrons which enter the material being processed and cause the desired radiation effect directly. When switched on, the unit emits a powerful beam of electrons to do the work; and, when it is turned off, the radiation ceases. Humans must be shielded when it is switched on. Otherwise, the equipment can be handled and transported like ordinary machinery,

and does not ever accidentally emit radiation. The replacement parts are handled and transported like ordinary goods, and can be kept at the customer's plant in ordinary storage.

There is an important economic distinction between the two ways of radiation processing. A linear-accelerator's parts wear out only when it is used. A radioactive source decays whether it is used or not. This characterization often forces owners of radioactive units to use them 24 hours per day, 7 days per week, all year long. This may add operational difficulties and extra labour expenses in running the plant.

4.5.1.2 Alternative Suppliers

Atomic Energy of Canada Ltd. produces irradiators which rely on a radioactive isotope - Cobalt 60 - to power their equipment. As previously noted, such radioactive sources have to be bought and replaced periodically by the customer because they decay and gradually lose their power. This means that they must be transported, stored, and disposed of properly.

Various companies have the capability to provide linear-accelerators. For example, Varian, Siemens, and Phillips are all fully occupied with supplying accelerator products to the cancer therapy market. As previously noted, when they are off, it is easier, safer, and cheaper for the maintenance staff and workers to service the machine or work in the surrounding area. Proponents of the linear-accelerator such as Accelerator Assoc, Ottawa, claim that their unit can be operated in ways that are more convenient to the owner and that minimizes labour costs. It is much more powerful per dollar of capital cost, and can be used for processes where speed is essential.

4.5.1.3 Summary

In our view, the use of irradiation technology represents a promising alternative for Pearson Airport, and warrants further investigation.

4.5.2 Ultra-violet Radiation

Recently on the upswing for the disinfection of water supplies, it is doubtful that this would be effective for solid wastes because of its relatively low power and physical awkwardness.

4.5.3 UV-Ozone

This technology is presently in the prototype stage in California, so does not represent a realistic option for Pearson.

5.0 RECOMMENDED COURSE OF ACTION

5.1 Short-Term Considerations

Since the Econoler/thermopress system has already been installed, the most practical course of action is to expedite the installation of the heat retention module and confirm this system's ability to effectively treat the airport waste while operating under the Agriculture Canada thermal guideline of 100°C for 30 minutes. This latter effort requires a rigorous testing program be set-up as soon as possible to verify all microorganisms in the waste residue have been rendered safe for landfilling (see discussion in Section 3.1.2 "Environmental Impact").

Secondly, installation upgrading criteria should be imposed immediately on the existing installation/proposal. Such criteria would include confirmation that the heat retention module has the capability to operate at higher temperatures. Testing may indicate the Agriculture Canada thermal target of 100°C for 30 minutes is insufficient to guarantee completely harmless residue.

Regardless of the residue test results, all items listed under section 3.1.2 "Environmental Impact" such as: occupational health and safety, public health concerns, waste water concerns, air pollution concerns, odour control, etc. should be addressed and remedied immediately.

Thirdly, the option of installing a mobile incineration system should be evaluated immediately. There are two main reasons for having a mobile incineration system installed as soon as possible:

- 1) to process all accumulated waste to date
- 2) to back up the Econoler thermopress system during their development and testing stages

The total accumulated international solid waste at the Airport for the month of August was approximately 720 to 900 tonnes. Approximately 50% of this quantity was processed by the present thermopress system, while 50% has remained unprocessed (this estimate based on thirty two containers (31 m³ each) observed containing unprocessed waste (density of 356 kg/m³).

If the realistic time frame for installation and the temperature capabilities of the heat retention module are unacceptable, the mobile incinerator option represents the only quick fix alternative. This alternative may require unilateral action by the Federal jurisdiction by-passing Ontario's Environmental Assessment Process requirement.

Finally, the Airport waste management systems presently in place should be reviewed in order to minimize the quantity of waste which requires heat treatment.

5.2 Long-Term Approach

Even if the Econoler/thermopress system is found to be capable of satisfactorily treating the Airport waste, based on a preliminary review of the economics of this system and the alternatives (see Table 3.4) there are several other alternatives that should be considered as a long term solution. To establish a long-term strategy, a feasibility study should be conducted, followed by preparation of appropriate bid documentation for tendering the most acceptable option(s).

The feasibility study would be required to define and develop the necessary information required to realistically assess the suitability of each of the alternatives for this application. The feasibility study should address the following:

- o Establish the waste quantities requiring special processing.
- o Establish minimum criteria for waste and residue handling procedures required for any alternative considered.
- o Prepare detailed capital and operating costs for realistic alternatives and prepare life cycle costing analysis.
- o Identify the track record on similar process applications and establish the level of risk associated with the alternatives.
- o Identify discharge rates expected for air emissions, waste water contaminants, odours, etc., together with other environmental impact concerns associated with specific alternatives.
- o Establish the extent of approvals requirements for each alternative and the effect on schedule for implementation of the schemes.
- o Review for each alternative, the facility size, location and overall aesthetics impact at the airport.

Considering the above, while the three alternatives described in this report (Econoler, Kenox, Waste Distillation Technology) should be included in the feasibility study, incineration, irradiation and autoclaving should also be reviewed for the long term solution, incineration being proven and widely used for this

application. Other alternatives may also have to be considered as discussed in section 4.

Although this report has dealt only with alternatives to incineration, MacLaren Engineers feel that incineration may represent the only reasonable long term solution to the airport waste problem and hence should be seriously considered in the feasibility study and tendering phases in the future.

With conclusion of the feasibility study and selection of the most realistic alternative(s) sufficient information would then be available to permit preparation of the necessary documentation required to competitive bid and select the optimal solution to this problem over the long term. The optimum solution in our view must be technically feasible, environmentally acceptable, and economically justified.

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